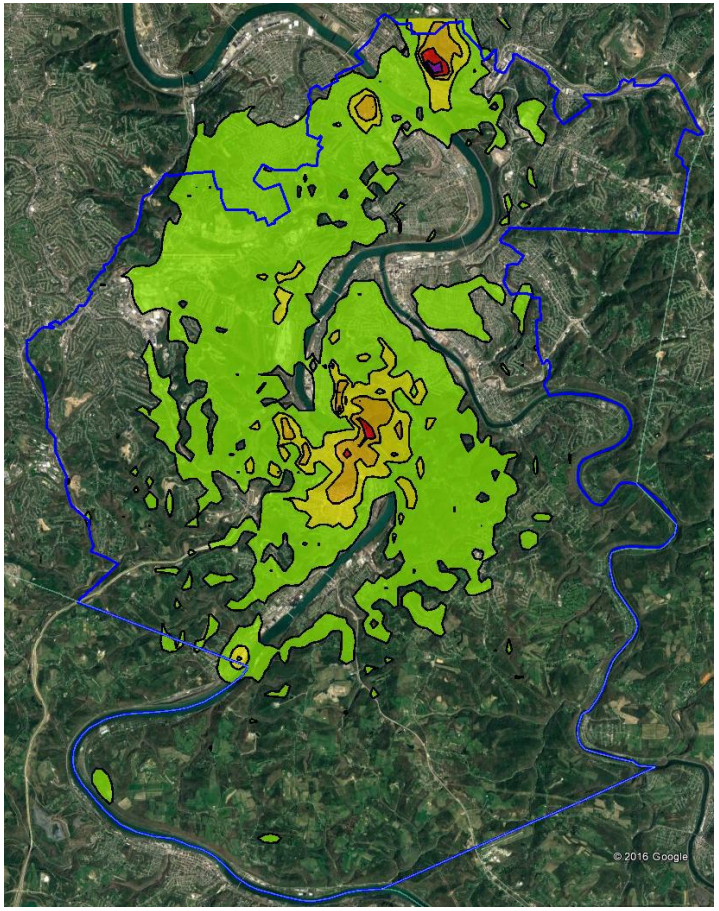
SIP Modeling Updates for Allegheny County, PA

2017 EPA Regional/State/Local Modelers' Workshop

Research Triangle Park, NC
Sept. 25-26, 2017



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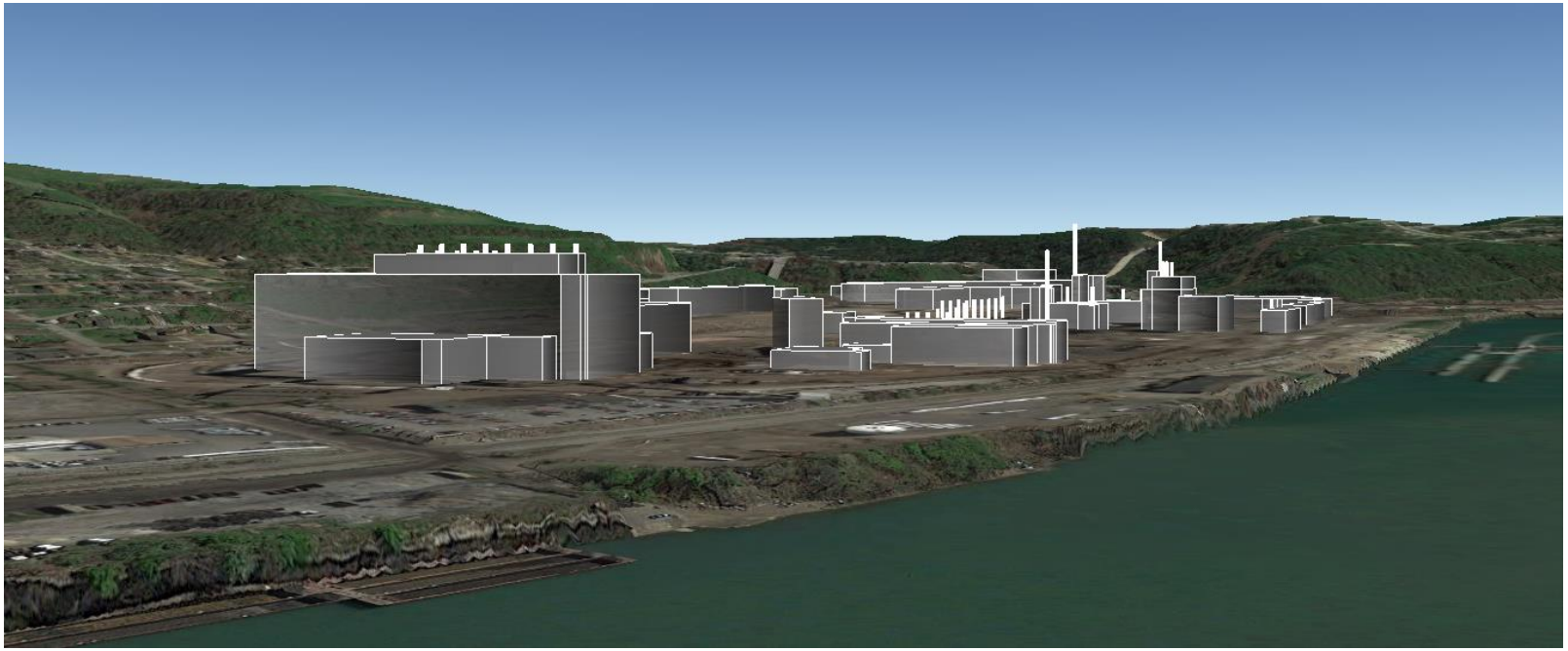
Recent SIPs in Allegheny County

- SO_2 SIP – 2010 NAAQS (Round 1 Area)
  - Final SIP completed on Sept. 14 – to be forwarded to EPA Region 3
  - Focused on controls for multiple steel manufacturing facilities
  - Complex terrain, non-steady-state processes/conditions
  - AERMOD with high-resolution MMIF (444 m) for meteorological inputs
  - Also used variable-height volumes for buoyant line fugitives

- SO_2 Round 3 (Data Requirements Rule)
  - 1 EGU identified in Allegheny County
  - Modeling option, at a revised allowable rate
  - Intended designation (120-day): unclassifiable

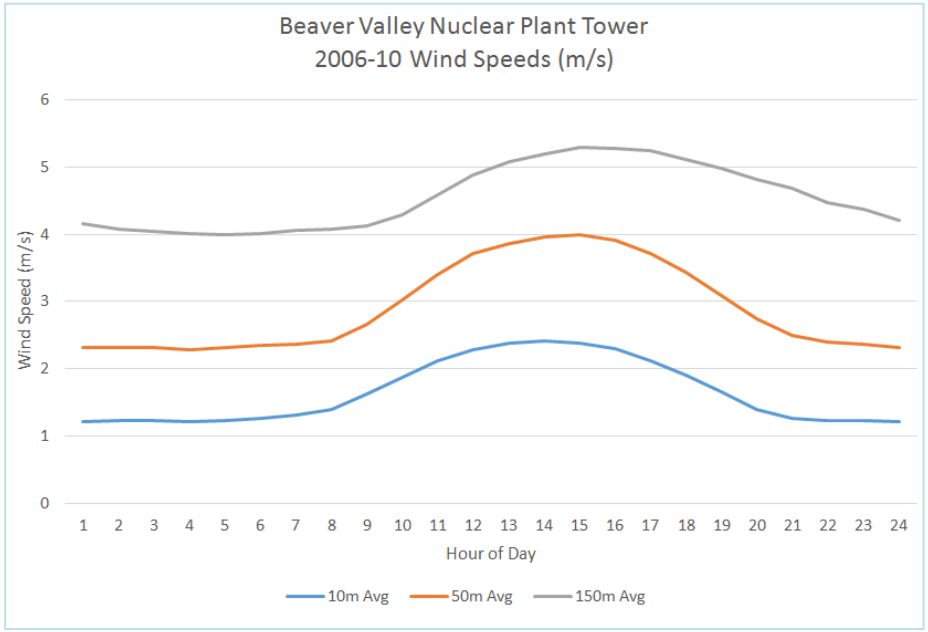
- $PM_{2.5}$ SIP – 2012 NAAQS
  - Allegheny County is nonattainment area
  - SIP under development
  - Focus is on regional and local reductions
  - Model: CAMx with Plume-in-Grid and PSAT

3-D Stacks/Buildings in Google Earth



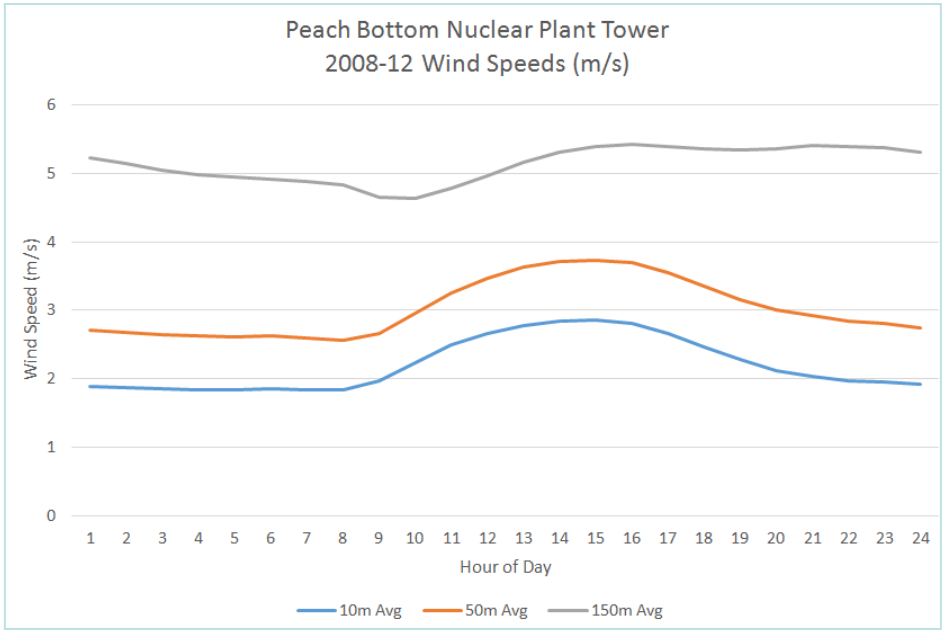
Multi-Level Towers, PA

Southwestern PA
(Ohio River Valley)



More complex terrain, more valley effects

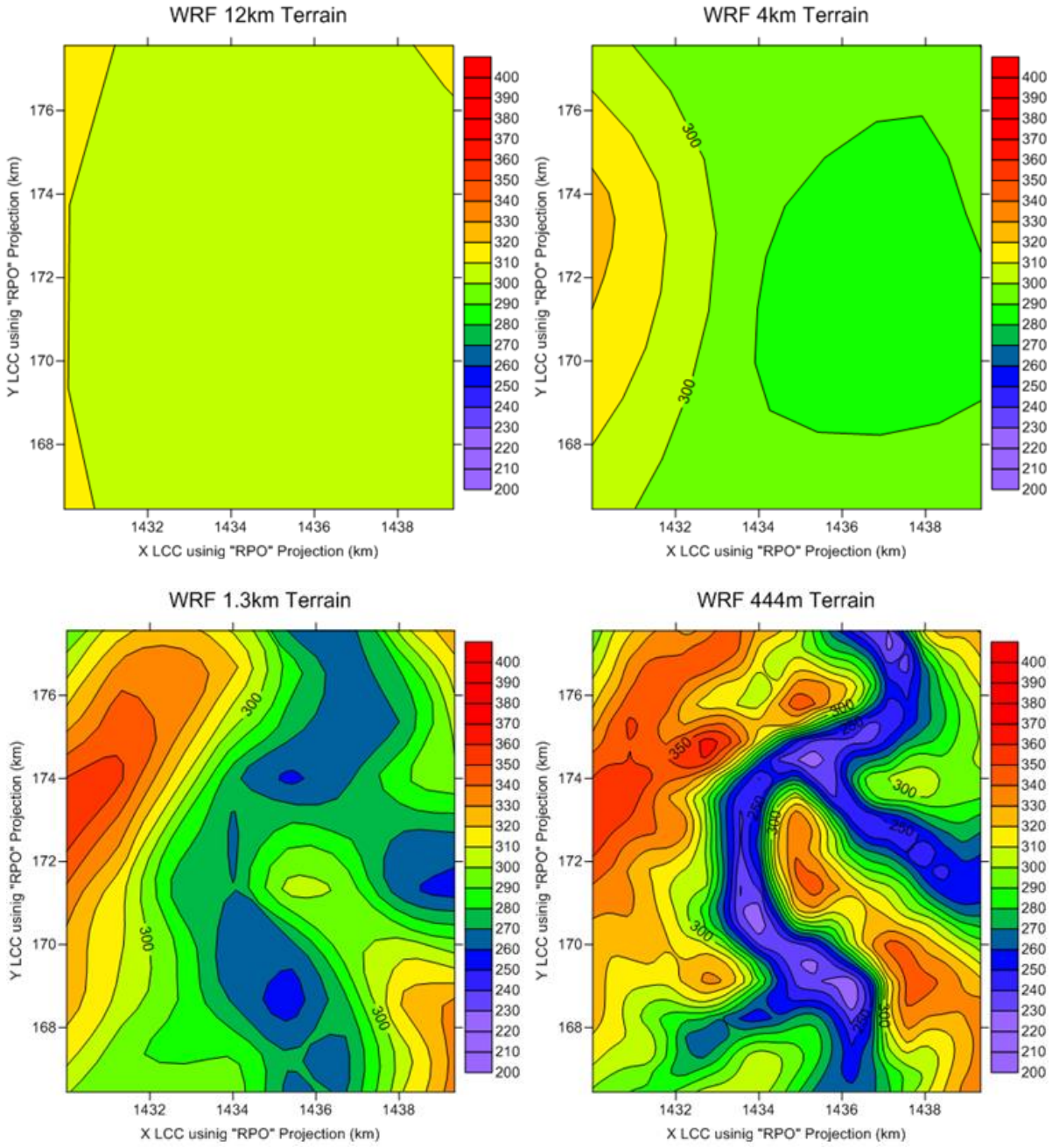
Southeastern PA
(Susquehanna River Valley)



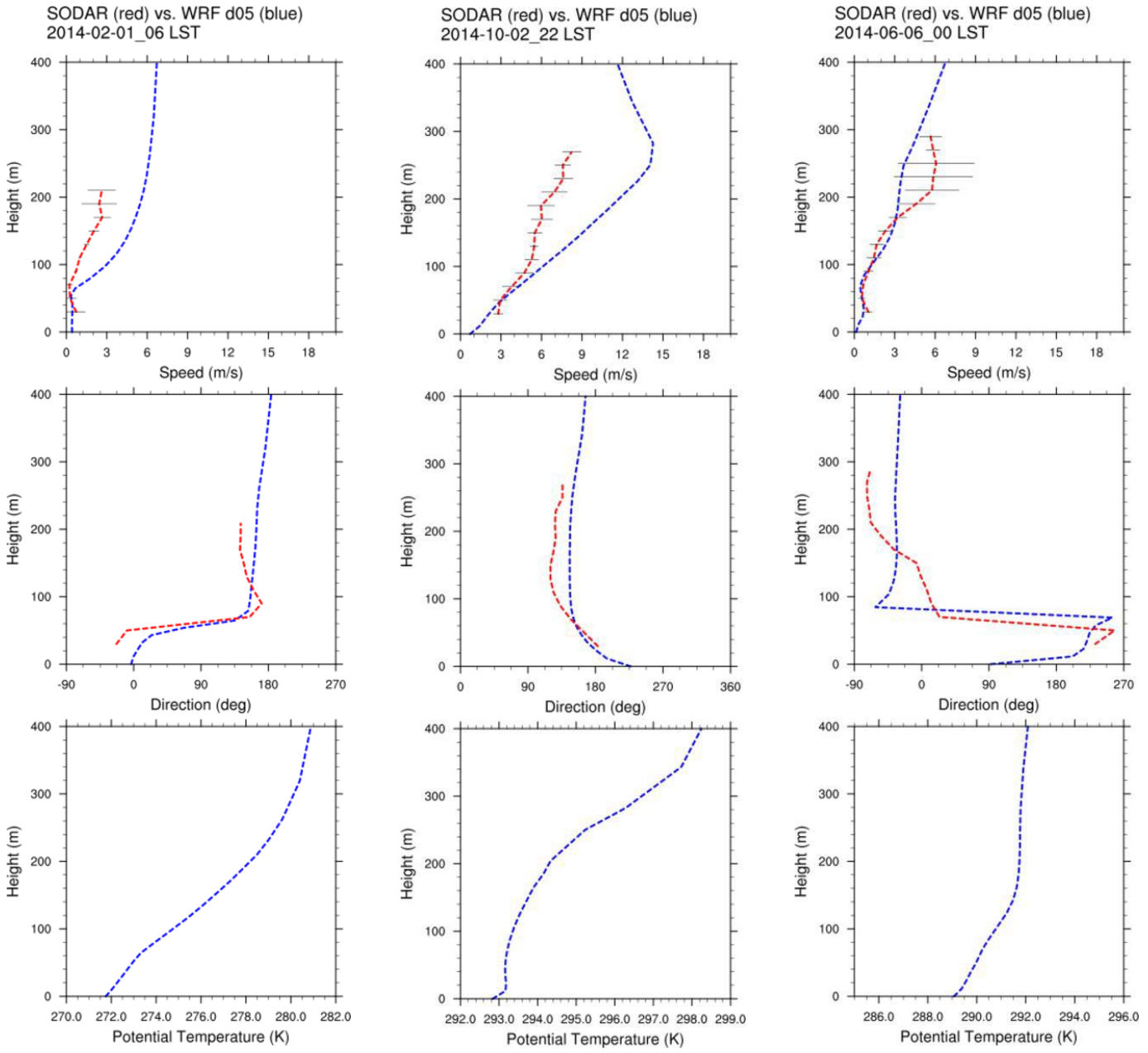
Less complex terrain, wider valley, more plateau winds

Figures supplied by EPA Region 3

WRF Terrain by Resolution



SODAR and WRF Vertical Profiles



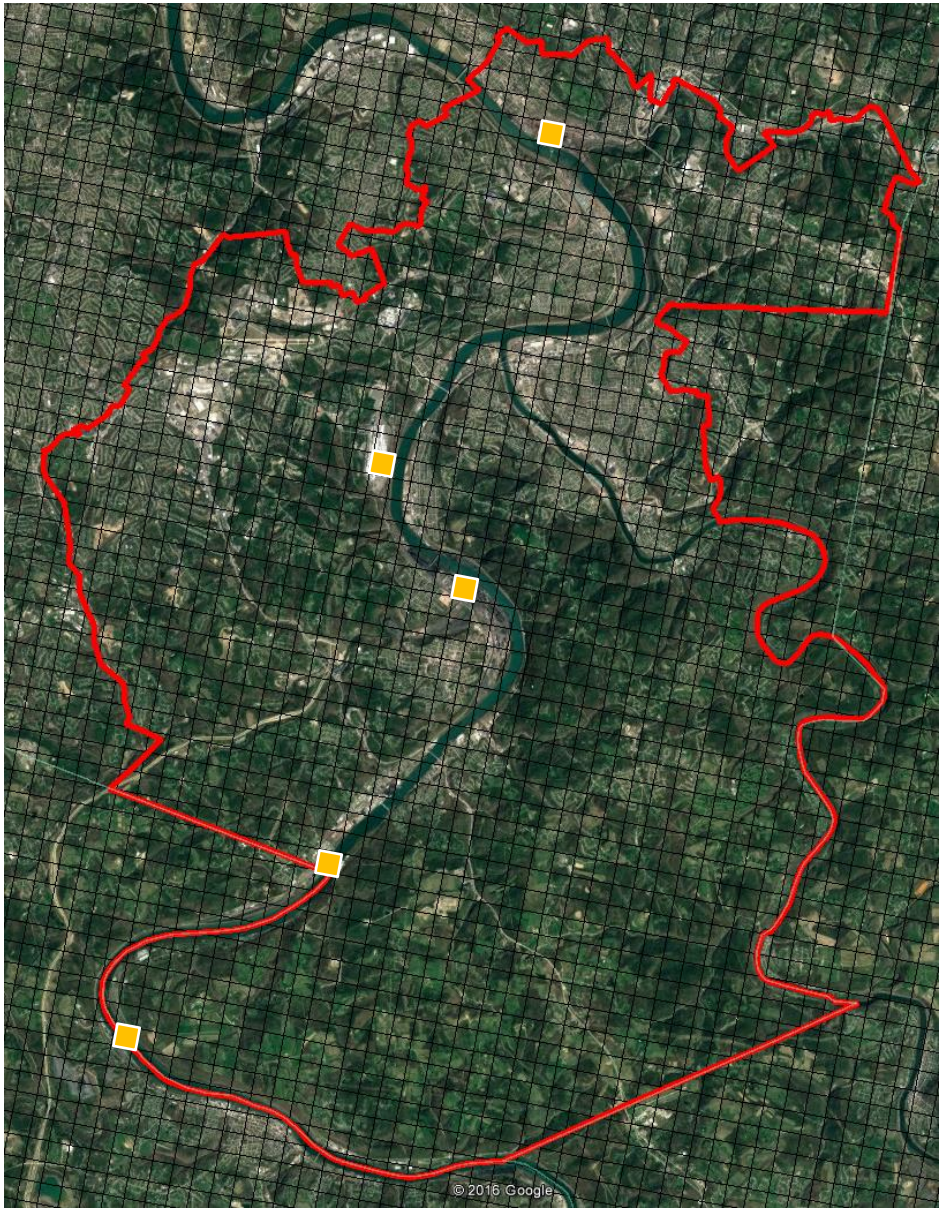
Wind Speed (Horizontal)

Wind Direction

Potential Temperature

MMIF Cells, 444 m Resolution

- MMIF generates prognostic onsite data (or “virtual tower”) at any grid cell
- Separate AERMOD runs are made for each source (combined in post-processing)
- In this case, MMIF cells are specific to locations in-valley but converge to similar patterns above-valley



MMIF Input Data

- Each MMIF grid cell contains unique onsite hourly data for:
  - Hourly wind/temp/rh profiles (to 5000 m)
  - Additional surface parameters
    - Mixing height (user option)
    - Also solar radiation, pressure, precipitation, delta-T
- Upper air
  - Can select more than 2 soundings per day (also unique to individual cells)
- Surface characteristics are based on MMIF grid cell averages
- MMIF output options
  - AERMET-ready: run onsite, upper air, and surface char. files through AERMET
  - AERMOD-ready: produces .sfc and .pfl files
- For SO_2 SIP, used AERMET-ready
  - Combination of WRF + AERMOD processing

Sample MMIF ONSITE Data

Date	Radiation	Mix Ht	Precip	Pressure		
2014010101	0.00	10.633	0.000	9970.150		
	Height	Speed	Direction	Temp	Rel Hum	Delta_T
	2.00			-4.956	78.120	0.093
	10.00	0.522	207.526			
	25.00	0.934	213.820	-4.863	77.000	
	50.00	2.149	212.922	-5.005	77.000	
	75.00	3.376	215.712	-4.938	76.000	
	100.00	4.083	222.074	-4.748	74.000	
	125.00	4.326	230.351	-4.650	73.000	
	150.00	4.450	236.244	-4.627	72.000	
	175.00	4.831	242.582	-4.563	71.000	
	200.00	5.544	249.042	-4.511	70.000	
	250.00	6.440	253.442	-4.650	69.000	
	300.00	7.424	256.889	-4.978	70.000	
	350.00	8.082	259.142	-5.233	71.000	
	400.00	8.932	261.605	-5.567	72.000	
	450.00	9.166	262.089	-5.677	73.000	
	500.00	10.436	264.322	-6.268	74.000	
	600.00	11.922	265.333	-6.770	74.000	
	700.00	12.858	265.762	-7.166	73.000	
	800.00	14.272	266.028	-8.039	69.000	
	900.00	14.860	266.418	-8.722	65.000	
	1000.00	16.498	269.127	-9.422	60.000	
	1500.00	21.025	274.290	-9.702	69.000	
	2000.00	27.142	278.312	-10.661	80.000	
	2500.00	32.620	279.947	-12.705	85.000	
	3000.00	34.990	280.333	-13.841	86.000	
	3500.00	37.083	279.095	-16.367	85.000	
	4000.00	38.604	278.286	-18.190	83.000	
	5000.00	43.552	275.047	-23.660	54.000	

Mixing Heights (MHGT)

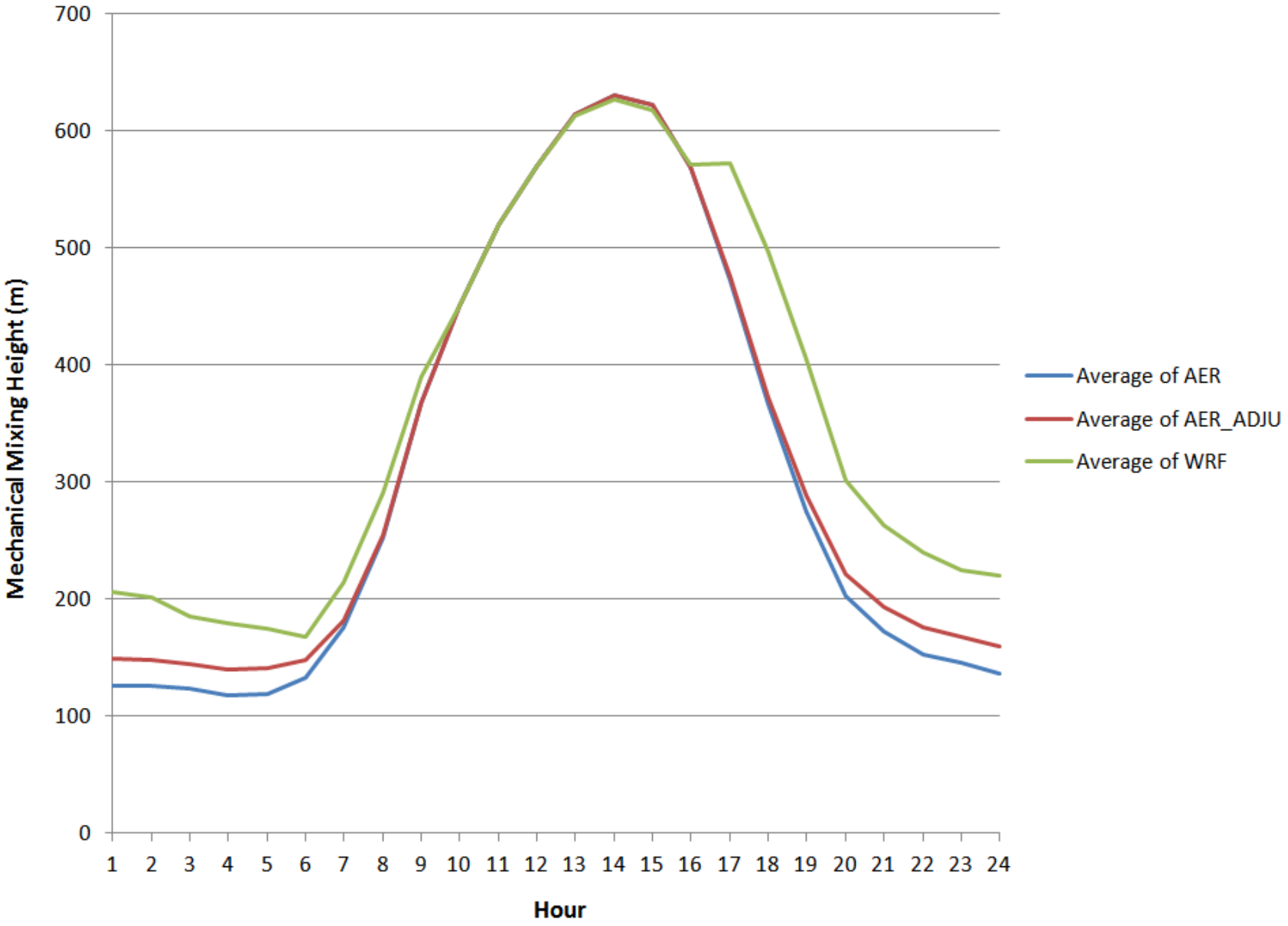
- With MMIF, user can select mixing height methodology
  - WRF, MMIF, or AERMET
  - If AERMET-ready mode, AERMET mixing height option omits MHGT (from WRF)

- AERMET processing can lead to very low mixing heights in general
  - Especially with multi-level data (MMIF, tower)
  - ADJ_U* increases mixing heights (if AERMET MHGT is selected)
    - Also modifies sensible heat flux (H) and M-O length
    - For MMIF only, cloud cover is also modified

- With MMIF met, ADJ_U* shows more subtle effect than with surface-based
  - WRF turbulence scheme is already “adjusting” u* to an extent
  - For impacts, WRF-based MHGT is similar to AERMET-based w/ADJ_U*

- For SO_2 SIP, AERMET-based MHGT w/ADJ_U* was selected
  - Most realistic hourly values
  - Best complement of WRF + AERMET

Hourly Avg Mech. Mixing Heights Using Different Options

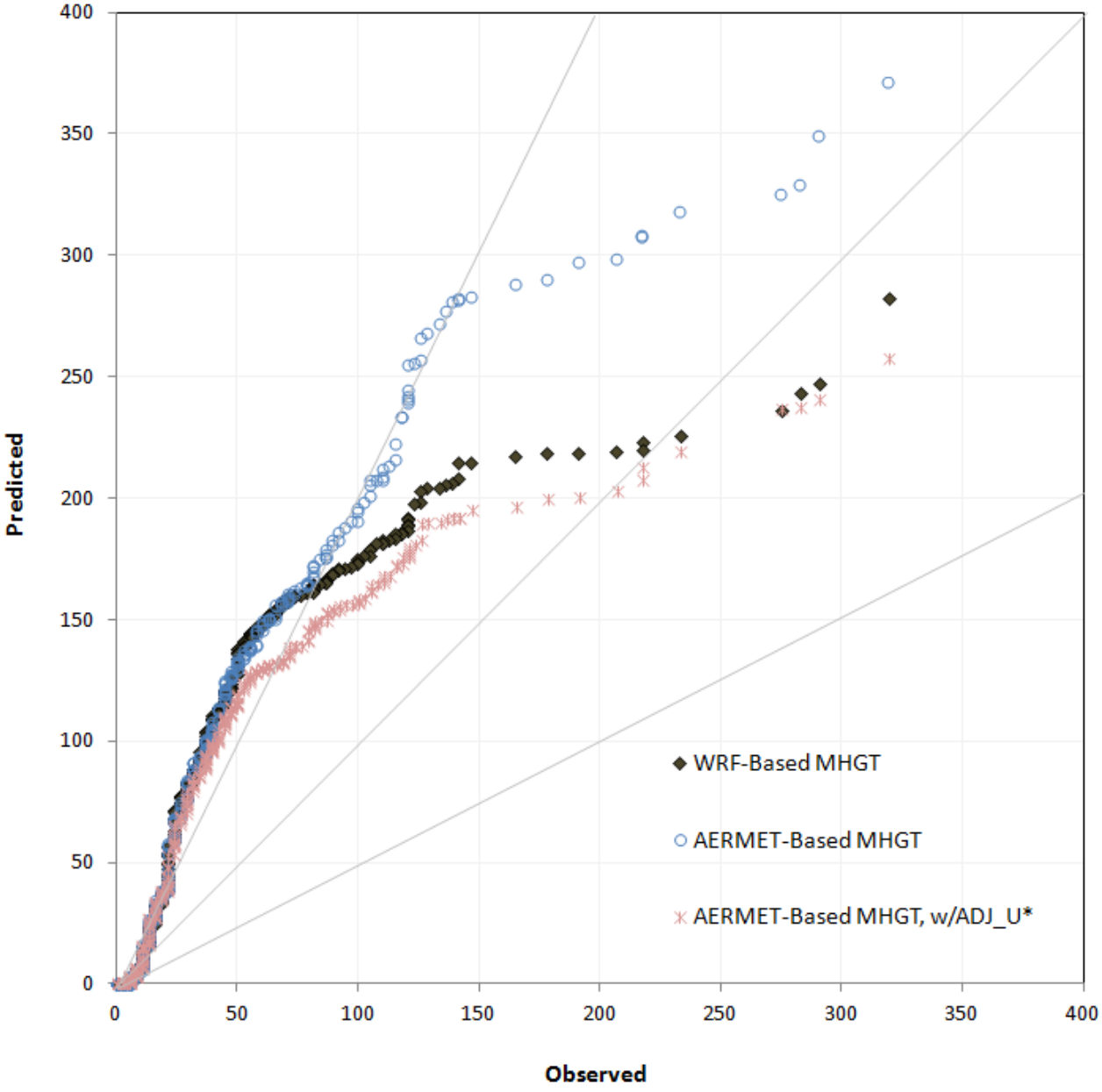


DEBUG MODEL Output, Different MHGTs

```
     YR/MN/DY/HR: 14010101

     Height assigned to midpoint of well-mixed layer for effective parameters =     5.5 meters.

     For effective parameter calculations: "Final" plume rise =     51.6479     m; Distance to final rise =     485.588     m
     Distance to well-mixed state =     296.861     m;
     "Effective" flow vector =  32.98
================================================================================

 YR/MN/DY/HR:  14010101

        <----------------- SOURCE INFORMATION ---------------> FINAL PLUME
 SOURCE    QS     TS       VS      DS    BUOY FLUX   MOM FLUX    HS       RISE
   #     (G/S)    (K)     (M/S)    (M)    (M4/S3)     (M4/S2)    (M)       (M)

   1       0.5   324.8   16.95    0.91        6.0        49.1   25.0      51.6

  VARIABLES AT       HEIGHT    WDIR    USCAL   URISE   SIGV    SIGW    DTHDZ
  STACK HEIGHT:        (M)     (DEG)   (M/S)   (M/S)   (M/S)   (M/S)  (DEG/M)

                      25.0    213.     1.16    1.16    0.20    0.02   0.0043
```

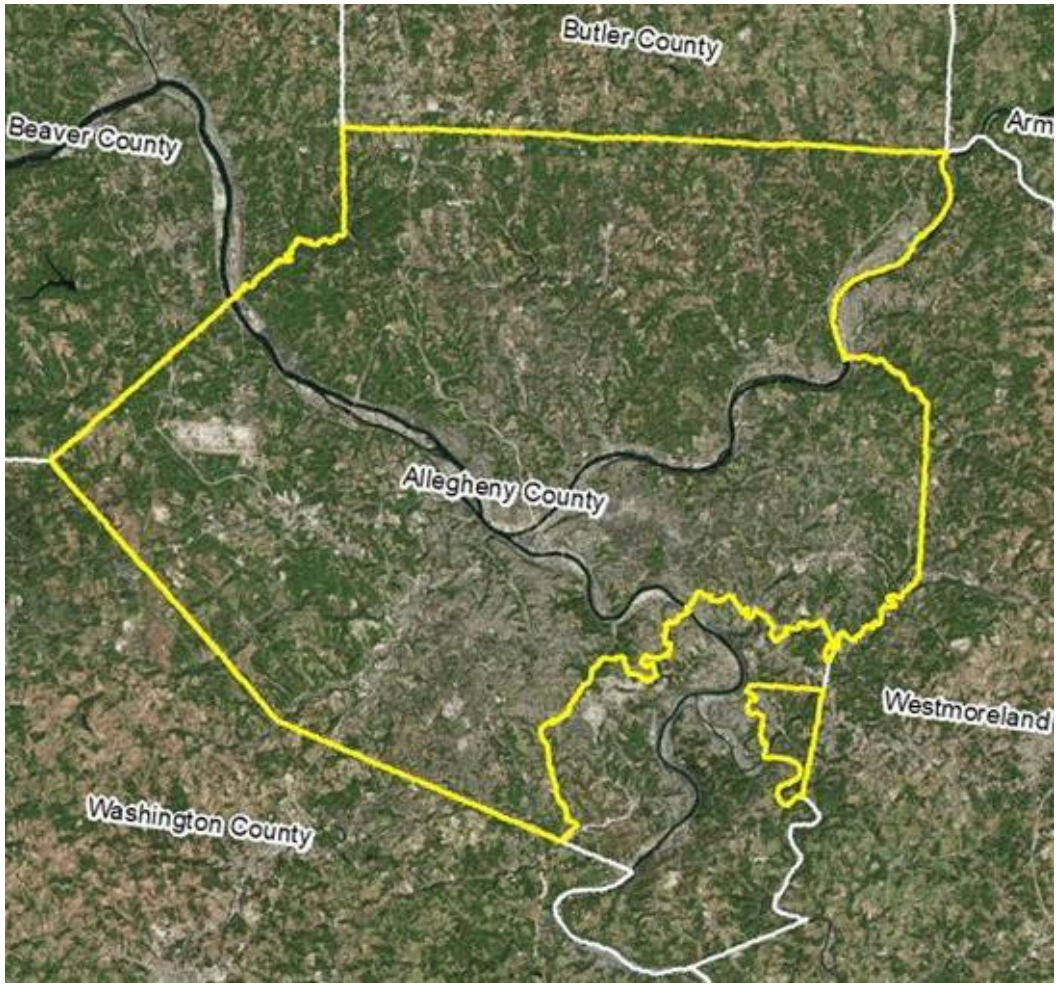
```
     YR/MN/DY/HR: 14010101

     Height assigned to midpoint of well-mixed layer for effective parameters =    13.0 meters.

     For effective parameter calculations: "Final" plume rise =     52.2171     m; Distance to final rise =     479.693     m
     Distance to well-mixed state =     410.330     m;
     "Effective" flow vector =  33.00
================================================================================

 YR/MN/DY/HR:  14010101

        <----------------- SOURCE INFORMATION ---------------> FINAL PLUME
 SOURCE    QS     TS       VS      DS    BUOY FLUX   MOM FLUX    HS       RISE
   #     (G/S)    (K)     (M/S)    (M)    (M4/S3)     (M4/S2)    (M)       (M)

   1       0.5   324.8   16.95    0.91        6.0        49.1   25.0      52.2

  VARIABLES AT       HEIGHT    WDIR    USCAL   URISE   SIGV    SIGW    DTHDZ
  STACK HEIGHT:        (M)     (DEG)   (M/S)   (M/S)   (M/S)   (M/S)  (DEG/M)

                      25.0    213.     1.17    1.17    0.20    0.03   0.0043
```

Mixing Height Effects on Performance



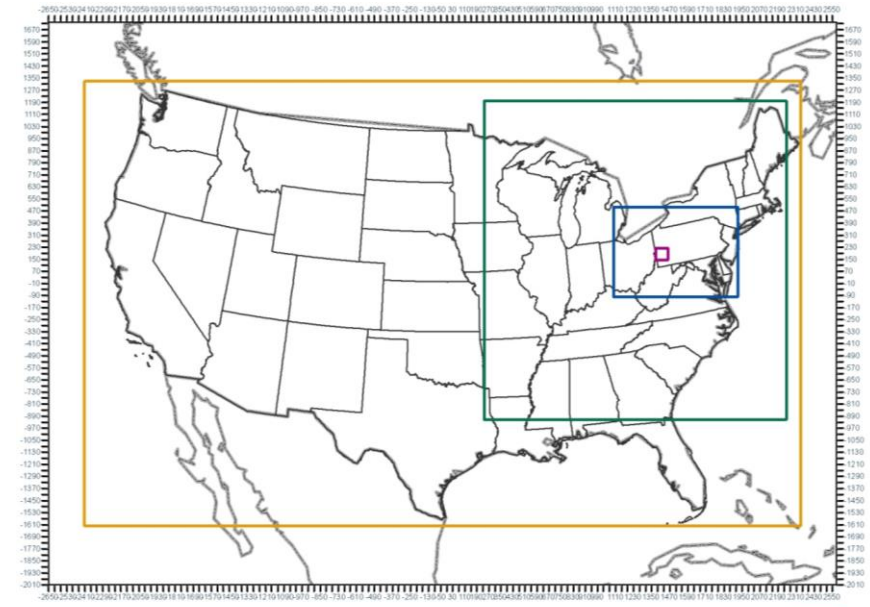
SO_2 Round 3 (DRR)

- Unclassifiable area in yellow (southeastern portion already a NAA)
- Modeling cannot be used as a basis for the designations
- Issues
  - Use of adjusted temperatures for enhanced buoyancy with FGD plume
  - Modeled emissions that do not reflect a current limit (or actual) emissions

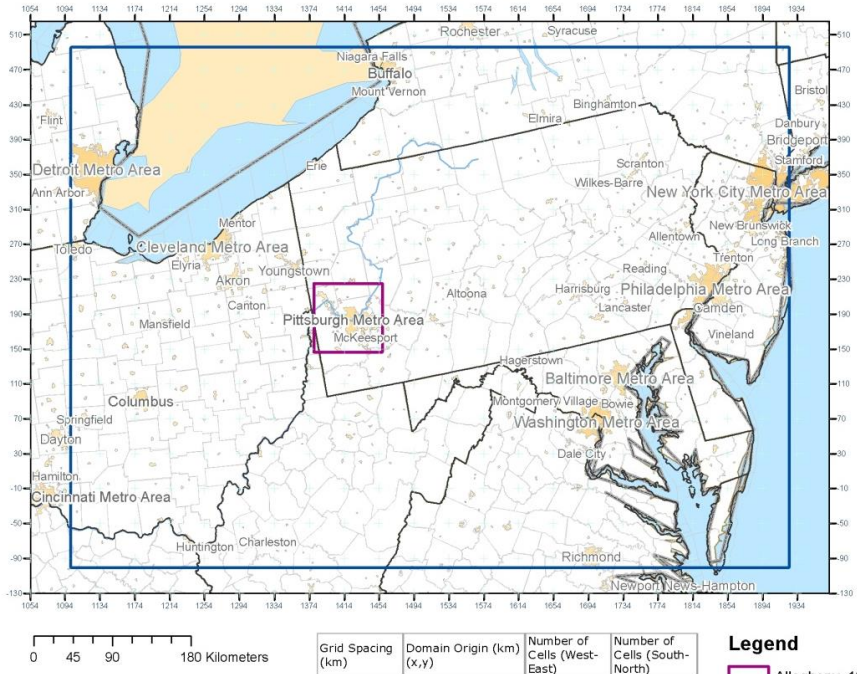


$PM_{2.5}$ SIP Development

- CAMx at 36/12/4/1.33 km resolution
  - Two-way nesting: between 36 and12 km, and between 4 and1.33 km domain
  - Special treatment for large near-field point sources



Grid Spacing (km)	Domain Origin (km) (x,y)	Number of Cells (West-East)	Number of Cells (South-North)
1.33 km	1378.67, 146.67	59	59
4 km	1100, -100	206	149
12 km	240, -912	167	176
36 km	-2412-1620	132	82

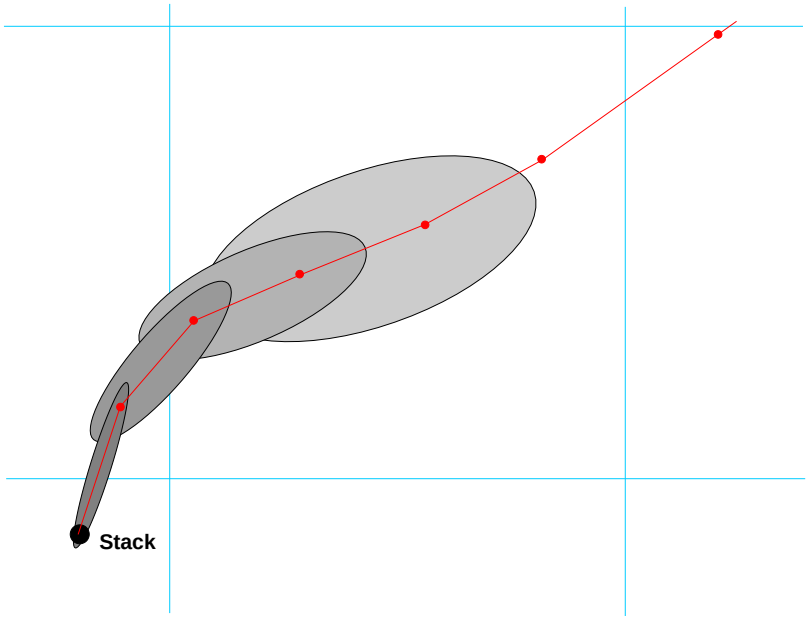


Grid Spacing (km)	Domain Origin (km) (x,y)	Number of Cells (West-East)	Number of Cells (South-North)
4 km	1100, -100	206	149
1.33	1378.67, 146.67	59	59

GEOS-Chem → (36 ↔ 12) → (4 ↔ 1.3)

CAMx with Plume-in-Grid (PiG) and PSAT

- CAMx Plume-in-Grid (PiG)
  - Subgrid-scale Gaussian Puff Module
  - Important for largest emitters near monitors
  - Treat near source chemistry and dispersion
  - Sample “live” puffs on hi-res near-field receptor network
  - Release puffs to grid when puff size is commensurate with grid size

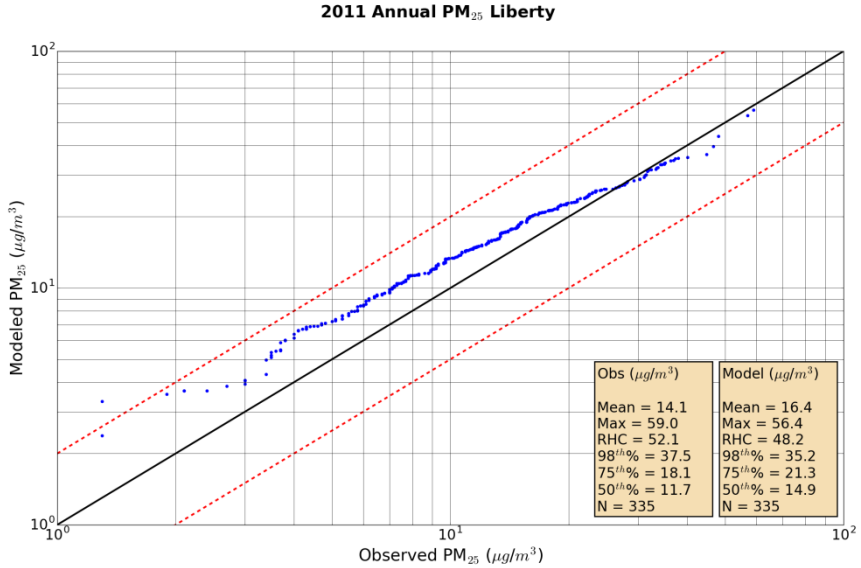


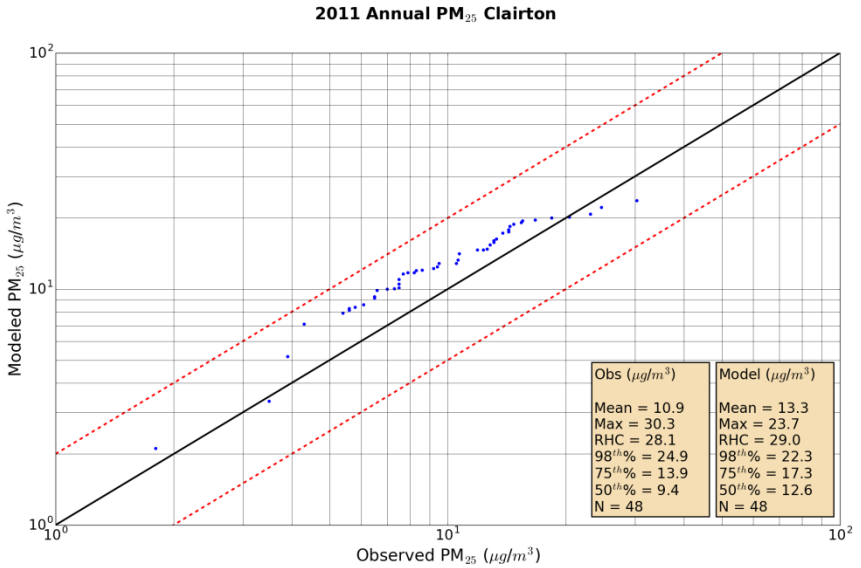
- CAMx Particulate Source Apportionment Technology (PSAT) Apportionment (probing tool)
  - Track local source PM concentrations in CAMx after mass is released from PiG puffs
  - CAMx gridded output + PiG live puffs gives total concentrations

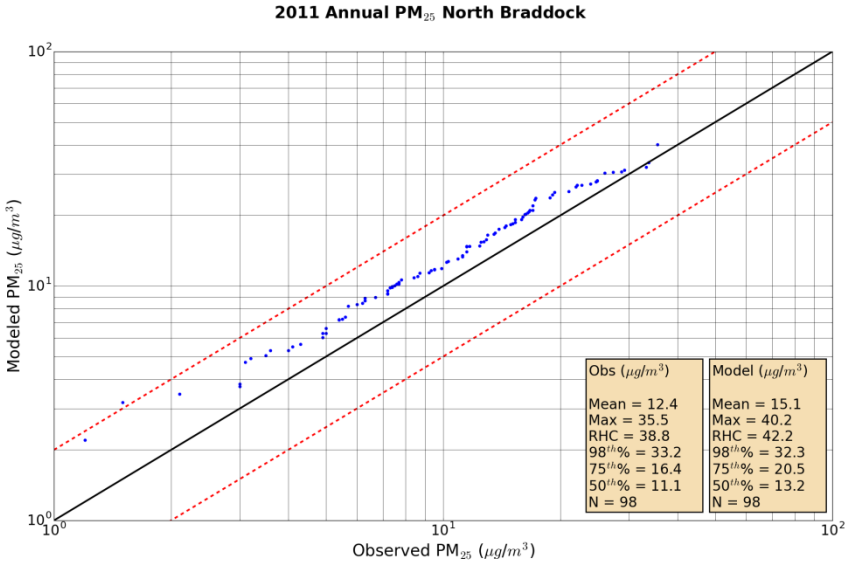
- Compare to localized impacts from AERMOD (hybrid approach)

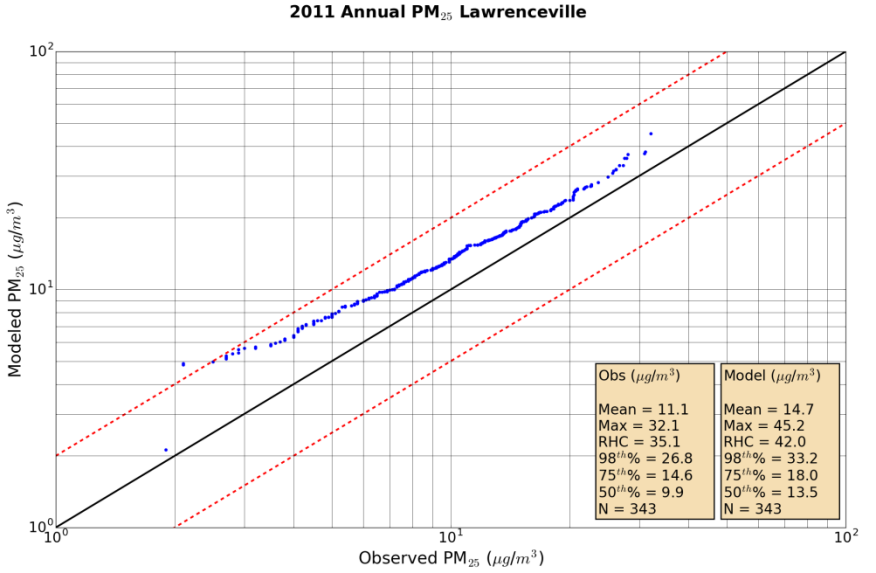
AERMOD-Equivalent Receptor Grid

Model Performance, CAMx w/PiG (2011 Base Year)









Additional/Future Work

- New Scintec SODAR-RASS to be deployed
- Carnegie Mellon University (CMU) computational fluid dynamics (CFD) study
- White papers and related topics
  - Low winds
  - Saturated plumes
  - Heat islands
  - Buoyant fugitives
  - Complex terrain
- Class I areas/visibility
- SCICHEM, other models
  - Non steady-state

Questions?

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